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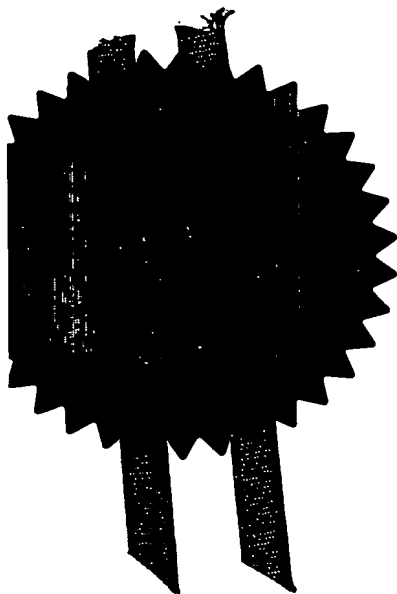
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23OCT02 E738006-170028847  
P01/7700 0-00-0224654.4**Request for grant of a patent**

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The Patent Office

Cardiff Road  
Newport  
South Wales  
NP10 8QQ

## 1. Your reference

P32450-/MGO/DBR/JAL

## 2. Patent application number

(The Patent Office will fill in this part)

0224654.4

## 3. Full name, address and postcode of the or of each applicant (underline all surnames)

Downhole Products plc  
Badentoy Road  
Badentoy Park  
Portlethen  
Aberdeen, AB12 4YA

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

7159176002

## 4. Title of the invention

"Apparatus"

## 5. Name of your agent (if you have one)

Murgitroyd &amp; Company

"Address for service" in the United Kingdom to which all correspondence should be sent (Including the postcode)

Scotland House  
165-169 Scotland Street  
Glasgow  
G5 8PL

Patents ADP number (if you know it)

1198015 ✓

## 6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
(if you know it)Date of filing  
(day / month / year)

## 7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
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## 8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if

Yes

a) any applicant named in part 3 is not an inventor, or  
b) there is an inventor who is not named as an applicant, or

c) any named applicant is a corporate body.

See note (d))

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0050687 23-Oct-02 04:28

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Description	21
Claim (s)	-
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Statement of inventorship and right to grant of a patent (Patents Form 7/77)	-
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11.

I/We request the grant of a patent on the basis of this application.

Signature MURGITROYD & COMPANY Date 23/10/02  
Murgitroyd & Company

12. Name and daytime telephone number of person to contact in the United Kingdom

Jamie Allen

01224 706616

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1     "Apparatus"

2

3     The present invention relates to a cement flow  
4     control tool and especially but not exclusively, a  
5     cement flow control tool for use in cementing a  
6     string of tubulars such as a casing or liner string  
7     into an oil, gas or water borehole.

8

9     Primary cementing is the process of placing cement  
10    in the annulus between a casing or liner string and  
11    the formations exposed to the borehole. A major  
12    objective of primary cementing is to provide zonal  
13    isolation in the borehole of oil, gas, and water  
14    wells, i.e. to exclude fluids such as water or gas  
15    in one zone from oil in another zone. To achieve  
16    this, a hydraulic seal must be obtained between the  
17    casing and the cement, and between the cement and  
18    the formations, while at the same time preventing  
19    fluid channels in the cement sheath. Without  
20    complete zonal isolation, the well may never reach  
21    its full producing potential and remedial work to  
22    repair a faulty cementing job may do irreparable

1 harm to the producing formation. In consequence,  
2 reserves may be lost and commencement of production  
3 may be delayed.

4  
5 After drilling the well to the desired depth, the  
6 drillpipe is removed and a casing string is run in  
7 until it reaches the bottom of the borehole. The  
8 casing string typically has a shoe, such as a float  
9 shoe, guide shoe or a reamer shoe on the end to  
10 guide the casing string into the borehole. At this  
11 time, the drilling mud (used to remove formation  
12 cuttings during the drilling of the well) is still  
13 in the borehole; this mud must be removed and  
14 replaced by hardened cement.

15  
16 This is done by passing cement down through the  
17 inside of the casing string; the cement passes out  
18 of apertures in the shoe and into the annulus  
19 between the borehole and the casing. The drilling  
20 mud is displaced upwards and the cement replaces it  
21 in the annulus. The cement needs to extend at least  
22 as far up the annulus so as to span the production  
23 zones, and the previous casing shoe if present, and  
24 sometimes the cement even extends to the surface.

25  
26 However, the cement is heavy and so exerts a large  
27 force on the drilling mud. Drilling mud is less  
28 heavy than cement, so the cement causes the drilling  
29 mud to travel quickly up the annulus. Fast flowing  
30 drilling mud brings a high pressure to bear upon the  
31 formation and excess solids and drill cuttings may  
32 build up in the annulus, exerting even more pressure

1 on the formation. The formation may break down  
2 under the pressure, resulting in both severe mud  
3 loss and also a loss of production. Open hole  
4 sections of the formation are especially prone to  
5 collapse, possibly ruining the borehole.

6

7 An additional problem is that the cement, being  
8 heavier, may also fall down through the drilling  
9 mud, resulting in a poor cement job.

10

11 According to the present invention there is provided  
12 apparatus for controlling the flow of cement into a  
13 borehole through a conduit, the apparatus comprising  
14 a decelerating means adapted to be positioned within  
15 the conduit for slowing down the flow of fluid  
16 through the conduit.

17

18 The deceleration means typically controls or  
19 mitigates the free fall effect of the cement.

20

21 Preferably, the conduit is a drillpipe, tubing,  
22 coiled tubing, casing or liner string, but may be  
23 any conduit which is inserted into a borehole.

24

25 Preferably, the decelerating means induces  
26 turbulence into the fluid to decelerate the fluid.

27

28 Typically, the decelerating means comprises a  
29 passage which is preferably an internal passage of  
30 the apparatus, and most preferably, the passage is  
31 defined by at least one body member having  
32 formations thereon.

1  
2 The internal passage typically comprises portions  
3 with axial and transaxial components, so that the  
4 length of the internal passage is greater than the  
5 length of the apparatus.

6  
7 The transaxial components of the internal passage  
8 typically cause the path of fluid flowing through  
9 the apparatus to deviate from its former axial path  
10 through the conduit prior to flowing through the  
11 apparatus, thereby decelerating the fluid.

12  
13 Preferably, the decelerating means further comprises  
14 at least one spiral passage defined by the at least  
15 one body member.

16  
17 Preferably, the internal passage is uni-directional  
18 in the axial direction, so that in use, when fluid  
19 is flowing from the top to the bottom of the  
20 internal passage, no part of the internal passage  
21 would direct fluid up the apparatus.

22  
23 Typically, the internal passage includes at least  
24 two portions spiralling in opposite directions to  
25 each other. Preferably, the spiral passage includes  
26 at least two of said portions and most preferably  
27 oppositely directed spiralling portions are  
28 positioned adjacent one another.

29  
30 Preferably, the internal passage includes two or  
31 more of said portions and most preferably, the  
32 passage is formed so that fluid travelling through a

5

1 first portion will flow in a clockwise direction  
2 through the spiralling parts of that portion, and  
3 fluid travelling through a second, neighbouring  
4 portion will flow in an anti-clockwise direction  
5 through its spiralling portion, or vice versa.

6  
7 Preferably, turbulence is wholly, mainly or partly  
8 induced by a direction altering means, which changes  
9 the direction of fluid flowing in the internal  
10 passage. Typically, the direction altering means  
11 comprises a cavity provided between first and second  
12 oppositely directed spiral passage portions,  
13 providing a space in which the fluid changes  
14 direction between the first spiral direction and the  
15 second spiral direction. The cavity is typically  
16 formed in the at least one body member and may  
17 comprise a connecting passage linking the spiral  
18 passage portions; the connecting passage may include  
19 axial portions and transaxial portions.

20  
21 Whether turbulent or laminar flow results depends  
22 (among other parameters) on the speed of the fluid  
23 through the passage.

24  
25 Optionally, the body members connect by interlocking  
26 means, which may include tongues and grooves.

27  
28 Optionally, the at least one body member is cemented  
29 or otherwise fitted inside the casing or liner  
30 string.

31

6

1 Typically, the apparatus is used in conjunction with  
2 equipment, such as a shoe and/or a float collar,  
3 having at least one one-way valve. Preferably, the  
4 cross-sectional area of the flow path through the  
5 internal passage is greater than the cross-sectional  
6 area of the flow path through the at least one  
7 valve.

8  
9 Thus, the rate of fluid leaving the shoe is not  
10 limited by the cross-section of the passage, only by  
11 the amount of turbulence created in the passage.

12  
13 Optionally, the apparatus includes at least one  
14 collar attached to an end (preferably the lower end)  
15 of the casing or liner string, the collar having  
16 screw threads for attachment to further sections of  
17 casing or liner.

18  
19 The collar can replace the shoe at the (in use)  
20 lower end of the apparatus. The collar may couple  
21 the casing or liner tubular within which the  
22 apparatus is inserted to further casing or other  
23 equipment, in the case that another piece of  
24 equipment is required directly above the shoe.

25  
26 A conventional coupling is typically used to attach  
27 the (in use) upper end of the casing or liner  
28 tubular within which the apparatus is located to the  
29 rest of the casing or liner string.

30  
31 Preferably, the apparatus comprises an anti-rotation  
32 means to prevent relative rotation of the body

1 members and thus the passage and the shoe.  
2 Typically, the anti-rotation means includes a  
3 device, which may be a sub, shaped to engage a bore  
4 provided in the shoe. Preferably, an axial locking  
5 means is provided to prevent axial separation of the  
6 device and the shoe. Preferably, the axial locking  
7 means comprises a latch provided on one of the  
8 device and the shoe, and a groove (to engage the  
9 latch) provided on the other of the device and the  
10 shoe. Most preferably, the locking means comprises  
11 a circlip provided on the device which is adapted to  
12 engage a groove in the shoe to prevent axial  
13 separation of the device and the shoe. Preferably,  
14 the anti-rotation means comprises a tapered edge  
15 provided on one of the device and the shoe and a  
16 correspondingly shaped groove provided on the other  
17 of the device and the shoe. Typically, the tapered  
18 edge is provided on the device and the groove is  
19 provided in the shoe. Typically, the anti-rotation  
20 means prevents relative rotation of the at least one  
21 body member and the shoe once the axial locking  
22 means has engaged.

23  
24 The anti-rotation means is useful to help prevent or  
25 restrict the rotation of the at least one body  
26 member and thus the passage when the at least one  
27 body member is drilled through. Rotation of the  
28 passage would be disadvantageous as rotation of the  
29 drill bit could rotate the passage, if it is not  
30 firmly cemented to the casing, instead of drilling  
31 through the passage.

32

1     Optionally, the apparatus further comprises an outer  
2     protection means, which may be a shroud. Typically,  
3     the outer protection means is provided with  
4     apertures in the side wall thereof.

5  
6     According to a second aspect of the present  
7     invention there is provided a method of controlling  
8     the passage of cement through a conduit located in a  
9     borehole, comprising passing a fluid through a  
10    decelerating means located inside the conduit, the  
11    decelerating means being adapted to decelerate the  
12    fluid passing through the conduit.

13  
14    Preferably, the decelerating means is inserted into  
15    the conduit prior to running in the conduit into the  
16    borehole.

17  
18    Preferably, the fluid is decelerated by induction of  
19    turbulence into the fluid.

20  
21    Typically, the turbulence is induced by passing the  
22    fluid through a passage, which may be a spiral  
23    passage, defined by the decelerating means.

24  
25    Preferably, the spiral passage includes portions  
26    spiralling in opposite directions and the turbulence  
27    is induced in a connection region between the  
28    portions where fluid spiralling in one direction has  
29    to change direction and spiral in the opposite  
30    direction.

31

1 Preferably, the spiral passage includes a plurality  
2 of oppositely directed spiralling portions  
3 positioned in series and the fluid passes through a  
4 plurality of connection regions as it flows through  
5 the conduit.

6  
7 Typically, the conduit includes a shoe attached to  
8 one end of the conduit, the shoe having a fluid  
9 outlet, and fluid is pumped or passed through the  
10 conduit and enters the borehole by the fluid outlet.

11  
12 Optionally, the passage has a shroud having  
13 apertures and pumping fluid through the passage  
14 causes some of the fluid to exit the passage through  
15 the apertures. Preferably, cement pumped or passed  
16 through the passage exits through the apertures to  
17 cement the decelerating means to the conduit.

18  
19 An embodiment of the invention will now be described  
20 by way of example only and with reference to the  
21 following drawings, in which:-

22 Fig 1 shows a side view with interior detail of  
23 two cement tools stacked on top of each other  
24 and inserted in a downhole assembly between a  
25 shoe and a casing string;

26 Fig 2 shows a side view with interior detail of  
27 the shoe of Fig 1;

28 Fig 3 shows a perspective view of a connector  
29 sub of Fig 1;

30 Fig 4 shows a side view with interior detail of  
31 a collar which can be used with the tool of Fig  
32 1;

10

1 Fig 5 shows a side view of a first tool  
2 portion;  
3 Fig 6 shows a side view of a second tool  
4 portion;  
5 Fig 7 shows a plan view of the rear (right  
6 hand) end of the second tool portion of Fig 6,  
7 rotated through 180°;  
8 Fig 8 shows a plan view of the front (left  
9 hand) end of the first tool portion of Fig 5;  
10 Fig 9 shows a side view with some interior  
11 detail exposed of one of the cement tools of  
12 Fig 1;  
13 Fig 10 shows a schematic diagram of the  
14 apparatus assembled in a borehole, with cement  
15 forcing the drilling mud through the apparatus;  
16 and  
17 Fig 11 shows a schematic diagram of the  
18 apparatus with displacement fluid forcing the  
19 cement through the apparatus.  
20  
21 Fig 1 shows apparatus in accordance with the present  
22 invention comprising a first cement tool 10 and a  
23 second cement tool 20 coupled together. Each tool  
24 10, 20 is made up of a first body member 30 having a  
25 left hand spiral portion and a second body member 40  
26 having a right hand spiral portion, shown in Figs 5,  
27 6, 7 and 8. It will, however, be appreciated that  
28 the left and right hand spiral portions may be  
29 swapped with one another.  
30  
31 The cement tools 10, 20 are located inside a length  
32 of casing 60, which has standard screw thread

11

1 connections on each end. The upper end of casing 60  
2 is connected to a casing coupling 12 which is  
3 attached to the rest of the casing string (not  
4 shown). It is not necessary for the tools 10, 20 to  
5 be located inside casing 60; the tools 10, 20 may be  
6 located inside any conduit which is inserted into  
7 the borehole, such as drillpipe, tubing, coil tubing  
8 or liner. The cement tools 10, 20, do not  
9 necessarily extend all the way up the length of  
10 casing 60 as shown in Fig 1; the cement tools 10, 20  
11 typically only extend approximately halfway up the  
12 length of casing 60.

13

14 Each body member 30, 40 has a central column 31, 41  
15 with a spiral protrusion 34, 44 extending therefrom.  
16 The radially outer edge of the spiral protrusions  
17 34, 44 extends substantially to the inner wall of  
18 the casing 60. Thus, a spiral passage 36, 46 is  
19 formed between the surfaces of the spiral protrusion  
20 34, 44, the central column 31, 41 and the inner  
21 surface of the casing 60.

22

23 The body members 30, 40 are connected together by  
24 inter-engaging tongues and grooves. Each body  
25 member 30, 40 has a dove tail or tongue 32 at one  
26 end (here, the upper end with respect to the  
27 borehole) and a groove 42 in the opposite end.  
28 However, in some embodiments, the positions of the  
29 tongues 32 and the grooves 42 are reversed. Each  
30 tongue 32 is dimensioned so that it is a tolerance  
31 fit with its respective groove 42 so that the

12

1 portions 30, 40, will not become accidentally  
2 disconnected in the borehole.

3  
4 The cement tools 10, 20 are connected together in  
5 the same way as the body members 30, 40; i.e. by  
6 connecting the tongue 32 of the second body member  
7 40 of the first tool 10 with the groove 42 of the  
8 first body member 30 of the second tool 20. A  
9 connecting passage 86 joins the spiral passages 36,  
10 46 of the body members 30, 40 together, as best  
11 shown in Fig 9. The connecting passage 86 is  
12 preferably cylindrical, having a first axial portion  
13 88 which extends from the (in use lower) end of  
14 spiral passage 46, a second axial portion 89 which  
15 extends from the (in use upper) end of the spiral  
16 passage 36 and a third transaxial portion 86A, 86B  
17 being a passage travelling through, and across the  
18 axis of, the cement tool 10, 20, connecting the  
19 first and second axial portions together. The first  
20 88 and second 89 axial passage portions are formed  
21 from a pair of off-centre axially arranged  
22 cylindrical bores formed respectively through the  
23 members 40, 30 and the third transaxial passage  
24 portion 86 is formed from a transaxially arranged  
25 cylindrical bore 86 formed through the body members  
26 30, 40 when joined together, so that the transaxial  
27 bore 86 spans the join between the body members 30,  
28 40.

29  
30 Fluid flowing through the cement tools 10, 20 will  
31 be decelerated by being forced to change from axial  
32 to spiral flow. In this embodiment, the cross-

13

1 section of the interior passage is smaller than the  
2 cross-section of the conduit, which will also cause  
3 deceleration of the fluid.  
4

5 The lower end of casing 60 is connected to a shoe 14  
6 by means of standard screw threads. The cement tool  
7 10 is connected inside the shoe 14 by an anti-  
8 rotation connector sub 16 (shown in Fig 3). The  
9 connector sub 16 has a groove 42 which engages the  
10 tongue 32 of the lower end of the first cement tool  
11 10. The connector sub 16 has a front portion 54 and  
12 a rear portion 56. Both portions 54, 56 are  
13 cylindrical but portion 56 has a larger diameter.  
14 The lower end of portion 56 tapers to a point to  
15 provide a tapered end 58. A circlip 62 is disposed  
16 in a groove in the front portion 54.  
17

18 The shoe 14 has an inner bore shaped to co-operate  
19 with the outside surface of the connector sub 16.  
20 The inner bore has a narrow portion 68 with a groove  
21 64 for engagement of the circlip 62. The inner bore  
22 of the shoe 14 also has a wider portion 69 having a  
23 V-shaped receiving surface 70 corresponding to the  
24 tapered end 58 to receive the tapered end 58.  
25

26 The connector sub 16 is inserted into the shoe 14  
27 and, once the circlip 62 is aligned with the groove  
28 64 in the inner bore of the shoe 14, the circlip 62  
29 expands into the groove 64. This prevents further  
30 axial movement between the shoe 14 and the connector  
31 16 (and hence the tools 10, 20 and the rest of the  
32 apparatus).

14

1  
2 The connector sub 16 can be inserted at any angle,  
3 as it will align itself due to the tapered end 58  
4 mating with the V-shaped receiving surface 70. Once  
5 the circlip 62 is engaged, the tapered end 58 cannot  
6 escape from the V-shaped receiving surface 70 as the  
7 axial movement needed to do this is prevented by the  
8 engaged circlip 62. Furthermore, the connector sub  
9 cannot rotate relative to the shoe 14 due to the  
10 mating of the tapered end 58 and the V-shaped  
11 receiving surface 70. Therefore, the shoe 14 is  
12 fixed relative to the cement tools 10, 20, both  
13 rotationally and axially.

14  
15 The shoe 14 has a nose 50 having outlet ports 52 to  
16 allow fluids to pass through the shoe 14 into the  
17 annulus between the casing and the borehole (not  
18 shown). The shoe 14 also typically has a one-way  
19 valve 55, to prevent fluids from flowing back into  
20 the casing string.

21  
22 The cross-section of the passage inside the tools  
23 10, 20 is preferably larger than the cross-section  
24 of the valve 55. This means that the fluid flow  
25 rate is not limited by the size of the valve 55.  
26 The fluid flow rate is only limited by the amount of  
27 turbulence created inside the tools 10, 20.

28  
29 Fig 4 shows a collar 80 which can be attached to the  
30 cement tool 10, instead of the shoe 14. The collar  
31 80 is typically used in the cases where it is not  
32 desired to connect the tools 10, 20 directly to the

15

1 shoe 14, e.g. if another tool is required to be  
2 inserted above the shoe 14. However, it will also  
3 be appreciated that the cement tools 10, 20 could be  
4 placed at any suitable position in the conduit by  
5 any suitable locating device such as adhesives etc.  
6 or even by providing the outer diameters of the  
7 cement tools 10, 20 as a clearance fit with the  
8 inner diameter of the conduit. Each end of the  
9 collar 80 is screw threaded for engagement with  
10 casing 60 and for engagement with further casing  
11 (not shown). The collar 80 has an inner bore  
12 similar to that of the shoe 14 for engagement with  
13 the connector sub 58. The inner bore has a narrow  
14 portion 68 with a groove 64 for engagement of the  
15 circlip 62 and a wide portion 69, having a tapered  
16 circumference 70 corresponding to the tapered end  
17 58. The collar 80 may be used to position the tools  
18 10, 20 above the shoe track 93 (the shoe track is  
19 shown in Figs 10 and 11). (The shoe track 93 is a  
20 common term in the industry to designate the  
21 combination of a shoe, one or two joints of casing  
22 and a float collar.)

23

24 Fig 9 shows the tool 10 having a shroud 82 around  
25 the exterior, which could be formed from an easily  
26 drillable material. The shroud 82 has apertures 84  
27 formed in its side wall. The apertures 84 are  
28 typically distributed throughout the surface of the  
29 shroud 82.

30

31 The shoe 14, the tools 10, 20, the connector sub 16,  
32 any collar 80 and any plugs used with the apparatus

16

1 are preferably made from materials which can be  
2 drilled through, such as a plastic or aluminium.  
3 The tools 10, 20 and connector sub 16 are preferably  
4 made out of a thermoplastic.

5  
6 In use, the shoe 14, connector sub 16, tools 10, 20,  
7 casing 60 and casing coupling 12 are connected to  
8 form the assembly shown in Fig 1 by engaging screw  
9 threads, tongues and grooves as described above.  
10 The assembly is then run into the borehole and  
11 drilling mud is pumped down through the casing  
12 string. When the assembly reaches the required  
13 depth, the casing is cemented in place. This is  
14 done by pumping cement down through the casing  
15 string. The cement is pumped on top of the drilling  
16 mud already in the casing string, and displaces the  
17 drilling mud, accelerating the mud down through the  
18 casing string and the tools 10, 20.

19  
20 The cement may be pumped directly on top of the  
21 drilling mud, in which case it could be advantageous  
22 to start with a low density cement slurry and to  
23 gradually build up the density. Cement additives  
24 (commercially available) have been developed to  
25 control the density of the cement slurry. The  
26 density can be lowered by adding an additive which  
27 has a low specific gravity, or which allows large  
28 quantities of water (which is lighter weight than  
29 cement) to be added to the cement, or a combination  
30 of both. The lead slurry should therefore be the  
31 lightest; typically around 10 lb/gallon, followed by

17

1 an intermediate slurry of around 11.5 lb/gallon, and  
2 a tail slurry of 15 lb/gallon.

3  
4 In this way, full density cement is not directly on  
5 top of the drilling mud, and this reduces the  
6 probability of the cement falling through the mud.  
7 The decelerating action of the tools 10, 20, which  
8 will be detailed subsequently, also reduces the  
9 likelihood that the cement will fall through the  
10 mud.

11  
12 Alternatively, as shown in Fig 10, a plug 90 could  
13 be positioned between the drilling mud 94 and the  
14 cement 92. The plug 90 typically has a sheer  
15 section 91 which breaks on the application of a  
16 threshold pressure. In the case where the tools 10,  
17 20 are located directly on top of the shoe 14, the  
18 plug 90 lands on top of the float collar 96. Fig 11  
19 shows the plug 90 landed and sheared by the pressure  
20 of the cement 92 above it. The float collar 96  
21 typically has an anti-rotation device (not shown),  
22 such as saw tooth protrusions, to engage the plug 90  
23 and to prevent rotation of the plug 90 when it is  
24 subsequently drilled through.

25  
26 The Fig 10 embodiment also shows the casing 60  
27 (which contains the cement tools 10, 20) and a  
28 following casing string 61 having commercially  
29 available centralisers 98 to hold the casing 60 and  
30 the casing string 61 in the centre of the borehole  
31 95.

32

18

1 In the case (not shown) where the tools 10, 20 are  
2 located above the shoe track 93 such that the tools  
3 10, 20 would be located in the casing string 61, a  
4 landing device (not shown) is typically provided to  
5 land the plug 90. The landing device would  
6 typically have an anti-rotation device to prevent  
7 rotation of the plug, as explained above.

8

9 Before the cement puts pressure on the drilling mud,  
10 the drilling mud flows slowly enough through the  
11 tools 10, 20 for the flow to be laminar. Thus, the  
12 tools 10, 20 do not restrict the flow of the  
13 drilling mud before the cement is introduced into  
14 the casing string; the only restriction on the flow  
15 of the drilling mud is the size of the valve 54.

16

17 However, when the mud is accelerated by the cement,  
18 the velocity of the mud is increased sufficiently  
19 for the drilling mud to become turbulent. As the  
20 drilling mud passes from the right-hand spiral  
21 portion 40 to the left-hand spiral portion 30, the  
22 drilling mud is forced to spiral in the opposite  
23 direction. Anticlockwise spiralling mud meets  
24 clockwise spiralling mud in the passage 82 between  
25 the portions 30, 40 such that eddy currents build up  
26 and the mud in the passage becomes turbulent. The  
27 turbulence restricts the flow of the mud through the  
28 tools 10, 20. Thus, the velocity of the mud which  
29 leaves the shoe and flows up the annulus between the  
30 casing and the formation is reduced, thereby  
31 exerting a reduced pressure on the formation and

19

1 reducing the probability of the formation breaking  
2 down..

3  
4 When the cement reaches the tools 10, 20, some of  
5 the cement flows through the apertures 84, which  
6 serves to cement the tools 10, 20 to the casing 60.

7  
8 Cement is continued to be pumped through the casing  
9 string until all the drilling mud 94 has been  
10 expelled from the shoe 14 and the cement 92 now  
11 fills the annulus between the casing string 61 and  
12 the borehole 95. A plug 102 is typically used to  
13 act as a separator between the cement 92 and a  
14 displacement fluid 100 (e.g. more drilling mud) used  
15 to propel the cement 92 downwards. Typically, this  
16 plug 102 lands on the float collar 96 (or the  
17 landing device, if the tools 10, 20 are located  
18 above the float collar 96), on top of any previous  
19 plug 90. Thus, when the cement 92 sets, in addition  
20 to filling the annulus, it will also fill all of the  
21 apparatus below the plug, including the tools 10,  
22 20.

23  
24 If deeper drilling is required, any plugs, the tools  
25 10, 20, any collar 80 and the shoe 14 are drilled  
26 through.

27  
28 Modifications and improvements can be made without  
29 departing from the scope of the invention. For  
30 example, more or fewer tools 10, 20 may be used in  
31 combination. The plastic or aluminium shroud 82 and  
32 the anti-rotation connector sub 16 are not essential

20

1 elements of the invention. For instance, the tools  
2 10, 20 could be cemented into the casing 60, or  
3 otherwise fixed to the casing 60 or the casing  
4 coupling 12, thus obviating the need for the anti-  
5 rotation connector sub 16.

6

7 Also, left-hand and right-hand spiral portions 30,  
8 40 need not be positioned alternately; two portions  
9 30 could be followed by two portions 40. The tool  
10 could optionally comprise only one spiral portion,  
11 or a combination of uni-directional spiral portions.  
12 In further alternative embodiments, the spiral  
13 portions 30, 40 could be replaced by a combination  
14 of straight axially arranged portions (not shown)  
15 and circumferentially arranged portions (not shown)  
16 such that the fluid would flow around a  
17 circumferential portion at one height and then flows  
18 down the straight axially arranged portion to the  
19 next lower circumferential portion and so on.

20

21 Furthermore the spiral portions 30, 40 need not be  
22 attached by tongues and grooves; other attachment  
23 means such as screw threads could be provided.

24

25 The shoe 14 could be any type of shoe such as a  
26 reamer shoe, a guide shoe or a float shoe.

27

28 The anti-rotation sub 16 is not an essential feature  
29 of the invention. In some embodiments, it is not  
30 necessary, e.g. the cement tools 10, 20 can be  
31 cemented, jammed or secured in any other way to the

21

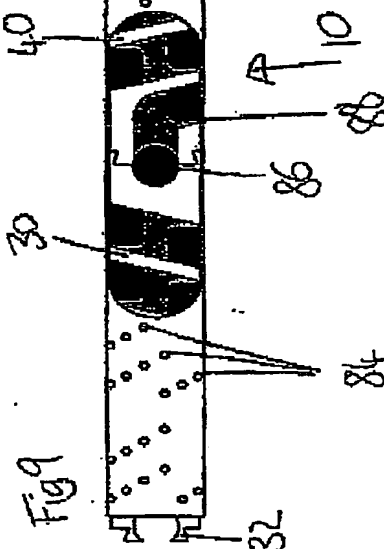
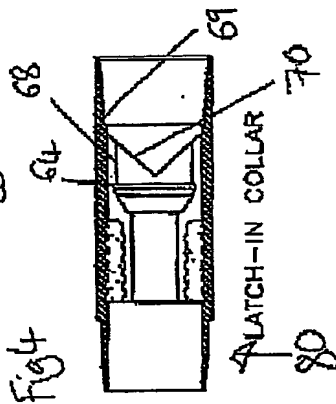
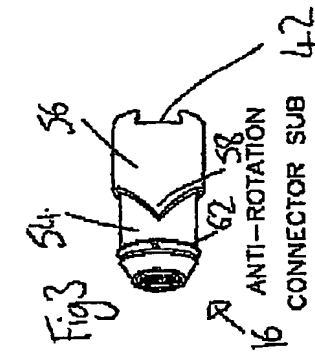
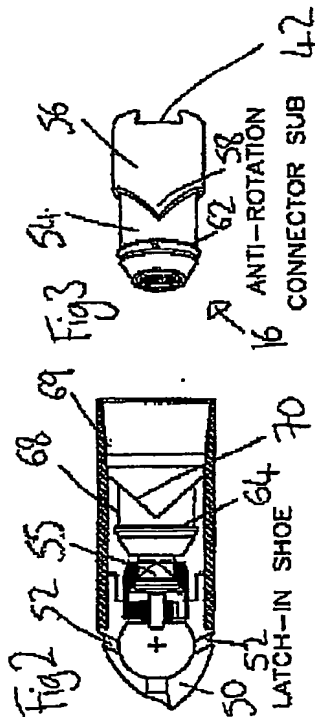
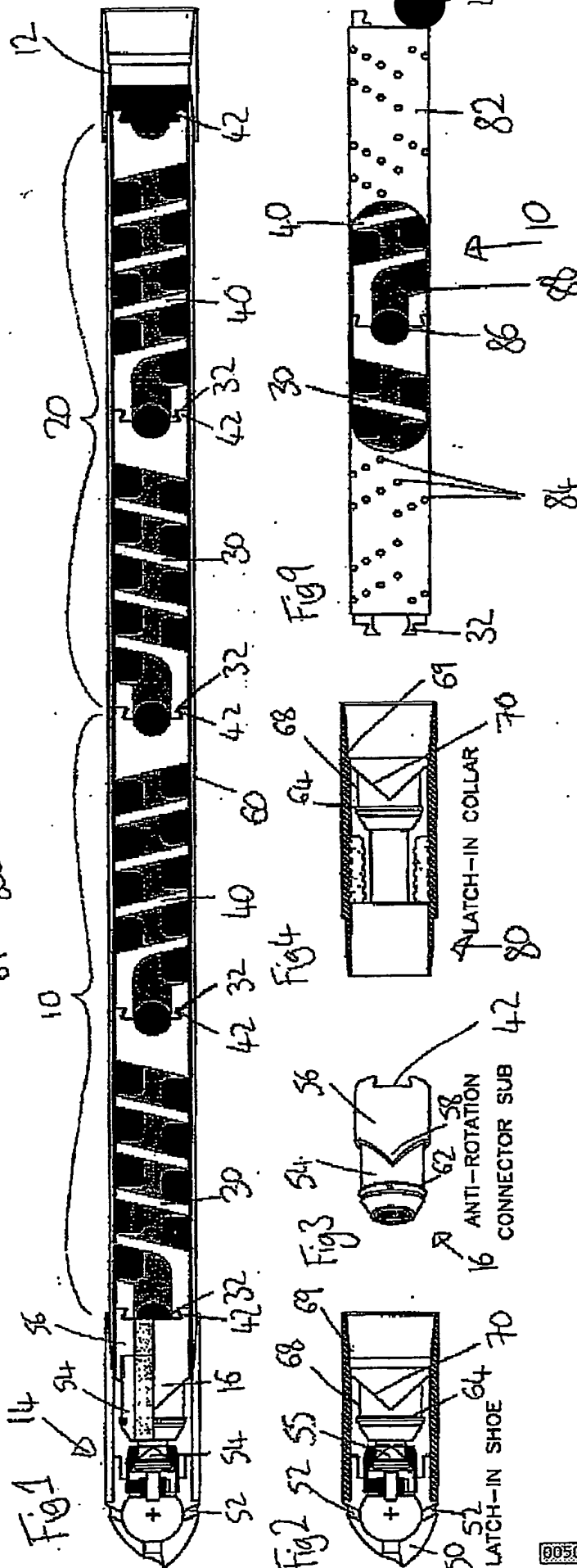
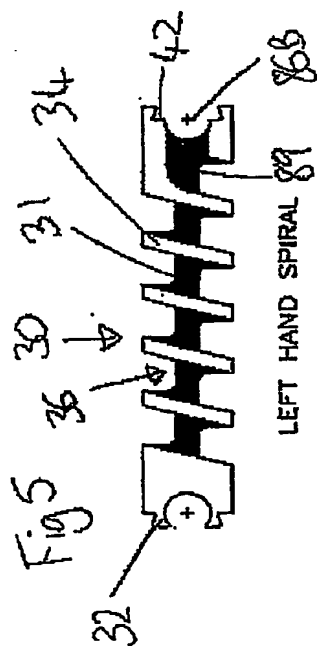
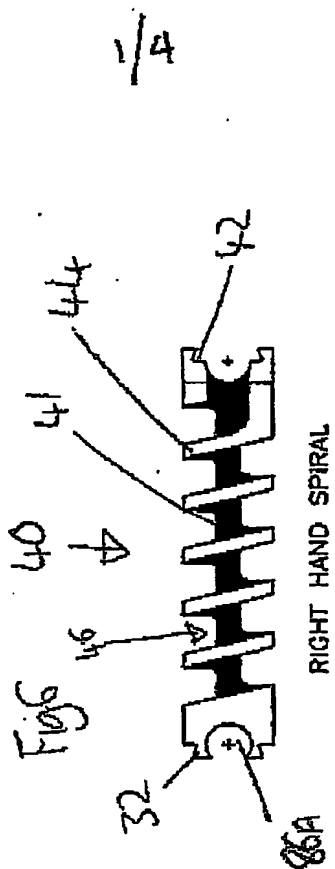
1 inside of the casing or other conduit so as to  
2 prevent rotation.

3

4 In the case where the cement tools 10, 20 are  
5 located inside drillpipe, neither the shoe 14 nor  
6 the collar 80 would be necessary. The drillpipe  
7 could be hung off (i.e. from a casing string) in  
8 such a way as to prevent rotation of the drillpipe.  
9 The cement tools 10, 20 could be dimensioned to be a  
10 clearance fit inside the drillpipe, to jam the tools  
11 10, 20 inside the drillpipe to prevent relative  
12 rotation therebetween.

13

14 The passage 86 between spiral portions 30 and 40  
15 could include a chamber wider than the rest of the  
16 passage in which the streams of oppositely flowing  
17 fluid could meet and interact.



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Fig 8



REAR END VIEW  
OF SPIRAL

Fig 7

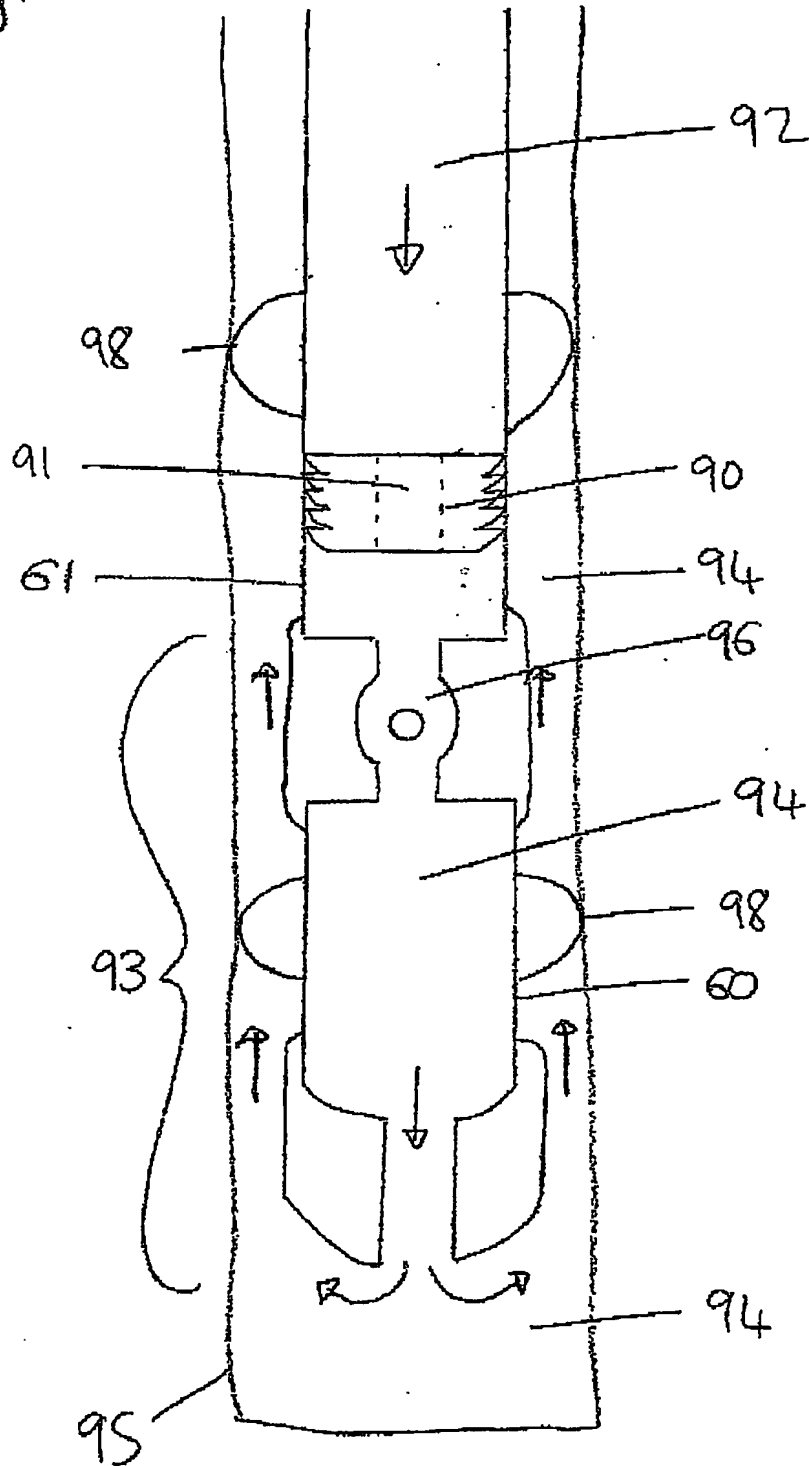


TOP END VIEW  
OF SPIRAL

rotated through  
180°

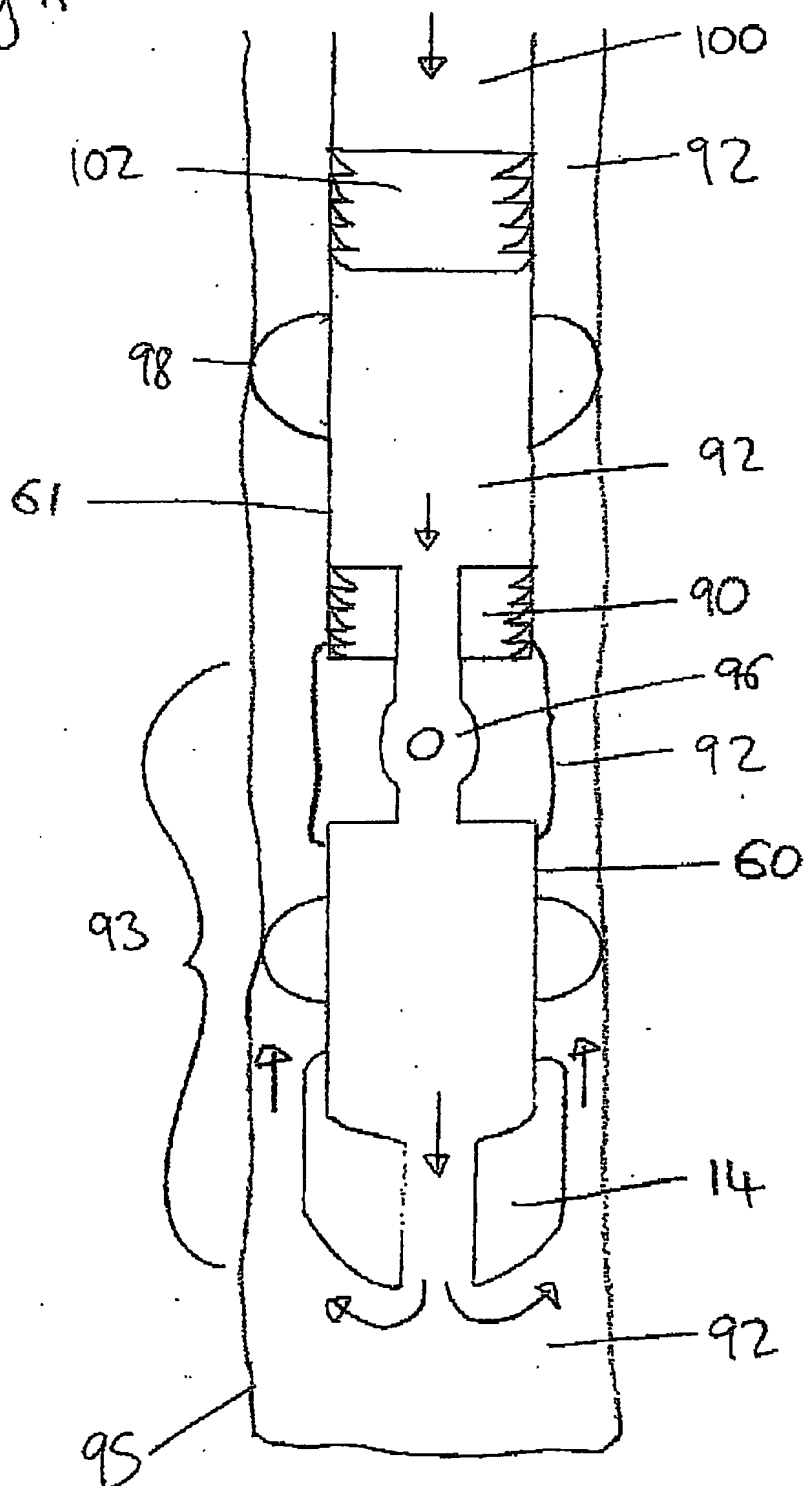
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Fig 10



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Fig 11



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